> # Pairwise Bootstrap

>

> plot(mtcars$wt, mtcars$mpg)

> x <- mtcars$wt

> y <- mtcars$mpg

>

> reg <- lm(y~x)

> abline(lm(reg))

>

> bhat <- reg$coefficients[2]

> n <- nrow(mtcars)

> num <- sum(((x - mean(x))^2)\*(reg$residuals^2))/n

> den <- sum((x - mean(x))^2)/(n-1)

> se <- sqrt(num)/den

>

> t <- sqrt(n)\*bhat / se

>

> B <- 999

> bstar <- rep(NA, B)

> tstar <- rep(NA, B)

>

> for (b in 1: B) {

+ index <- sample(1:nrow(mtcars), size = n, replace=TRUE)

+ xstar <- mtcars$wt[index]

+ ystar <- mtcars$mpg[index]

+

+ regstar <- lm(ystar~xstar)

+ bstar[b] <- regstar$coefficients[2]

+

+ numstar <- sum(((xstar - mean(xstar))^2)\*(reg$residuals^2))/n

+ denstar <- sum((xstar - mean(xstar))^2)/(n-1)

+ sestar <- sqrt(numstar)/denstar

+

+ tstar[b] <- sqrt(n)\*(bstar[b] - bhat) / sestar

+ }

>

> tstar <- sort(tstar)

> hist(tstar, breaks = 30, probability = TRUE, col = "grey", main = "Distribution of t\*", xlim = c(-9, 9))

> lines(density(tstar), col = "red", lwd = 3)

> cv <- c(tstar[25], tstar[975])

> abline(v = c(cv, t), col = c("blue"), lty = c(2, 2, 1), lwd = 3)

>

> print(paste("t stat is", round(t,3)))

[1] "t stat is -8.706"

> print(paste("5% pairwise bootstrap critical values are", round(cv[1], 3), "and", round(cv[2], 3)))

[1] "5% pairwise bootstrap critical values are -2.694 and 2.4"

>

>

>

>

>

> # Residual Bootstrap

>

> plot(mtcars$wt, mtcars$mpg)

> x <- mtcars$wt

> y <- mtcars$mpg

>

> reg <- lm(y~x)

> abline(lm(reg))

>

> bhat <- reg$coefficients[2]

> n <- nrow(mtcars)

> num <- sum(((x - mean(x))^2)\*(reg$residuals^2))/n

> den <- sum((x - mean(x))^2)/(n-1)

> se <- sqrt(num)/den

>

> t <- sqrt(n)\*bhat / se

>

> B <- 999

> bstar <- rep(NA, B)

> tstar <- rep(NA, B)

>

> for (b in 1: B) {

+ index <- sample(1:nrow(mtcars), size = n, replace=TRUE)

+ xstar <- x

+ ustar <- reg$residuals[index]

+ ystar <- reg$coefficients[1] + reg$coefficients[2] \* xstar + ustar

+

+ regstar <- lm(ystar~xstar)

+ bstar[b] <- regstar$coefficients[2]

+

+ numstar <- sum(((xstar - mean(xstar))^2)\*(regstar$residuals^2))/n

+ denstar <- sum((xstar - mean(xstar))^2)/(n-1)

+ sestar <- sqrt(numstar)/denstar

+

+ tstar[b] <- sqrt(n)\*(bstar[b] - bhat) / sestar

+ }

>

> tstar <- sort(tstar)

> hist(tstar, breaks = 30, probability = TRUE, col = "grey", main = "Distribution of t\*", xlim = c(-9, 9))

> lines(density(tstar), col = "red", lwd = 3)

> cv <- c(tstar[25], tstar[975])

> abline(v = c(cv, t), col = c("blue"), lty = c(2, 2, 1), lwd = 3)

>

> print(paste("t stat is", round(t,3)))

[1] "t stat is -8.706"

> print(paste("5% residual bootstrap critical values are", round(cv[1], 3), "and", round(cv[2], 3)))

[1] "5% residual bootstrap critical values are -2.362 and 2.655"

>

>

>

>

>

> # Wild Bootstrap

>

> plot(mtcars$wt, mtcars$mpg)

> x <- mtcars$wt

> y <- mtcars$mpg

>

> reg <- lm(y~x)

> abline(lm(reg))

>

> bhat <- reg$coefficients[2]

> n <- nrow(mtcars)

> num <- sum(((x - mean(x))^2)\*(reg$residuals^2))/n

> den <- sum((x - mean(x))^2)/(n-1)

> se <- sqrt(num)/den

>

> t <- sqrt(n)\*bhat / se

>

> B <- 999

> bstar <- rep(NA, B)

> tstar <- rep(NA, B)

>

> for (b in 1: B) {

+ u\_modify <- sample(c(1, -1), size = n, replace=TRUE)

+ xstar <- x

+ ustar <- reg$residuals \* u\_modify

+ ystar <- reg$coefficients[1] + reg$coefficients[2] \* xstar + ustar

+

+ regstar <- lm(ystar~xstar)

+ bstar[b] <- regstar$coefficients[2]

+

+ numstar <- sum(((xstar - mean(xstar))^2)\*(regstar$residuals^2))/n

+ denstar <- sum((xstar - mean(xstar))^2)/(n-1)

+ sestar <- sqrt(numstar)/denstar

+

+ tstar[b] <- sqrt(n)\*(bstar[b] - bhat) / sestar

+ }

>

> tstar <- sort(tstar)

> hist(tstar, breaks = 30, probability = TRUE, col = "grey", main = "Distribution of t\*", xlim = c(-9, 9))

> lines(density(tstar), col = "red", lwd = 3)

> cv <- c(tstar[25], tstar[975])

> abline(v = c(cv, t), col = c("blue"), lty = c(2, 2, 1), lwd = 3)

>

> print(paste("t stat is", round(t,3)))

[1] "t stat is -8.706"

> print(paste("5% wild bootstrap critical values are", round(cv[1], 3), "and", round(cv[2], 3)))

[1] "5% wild bootstrap critical values are -2.34 and 2.278"